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Bibliography

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- (54) [Title of the Invention] Lightwave signal transmitter
- (51) [International Patent Classification (6th Edition)]

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H04N 7/22

H04B 9/00 C

L

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[Identification Number] 000004226

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[Patent Attorney]

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[Judge] \*\* name One husband

(56) [Reference]

[References] Provisional publication of a patent Taira 4-123543 (JP, A)

[References] Provisional publication of a patent Showa 57-27233 (JP, A)

[References] Provisional publication of a patent Taira 4-346525 (JP, A)

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CLAIMS

(57) [Claim(s)]

[Claim 1] The lightwave signal transmitter characterized by providing the following. The optical frequency modulation section which considers an electrical signal as a modulation input and outputs the lightwave signal by which frequency modulation was carried out The optical frequency local oscillation section which outputs the local oscillation light of optical frequency which left only this lightwave signal and intermediate frequency The optical multiplexing section which multiplexes said lightwave signal and said local oscillation light An optical transmitting means to output the lightwave signal which carries out intensity modulation of the light source to the optical-heterodyne-detection section which inputs this lightwave signal it was multiplexed [ lightwave signal ] and outputs the electrical signal of an intermediate frequency equal to the difference of the optical frequency of said lightwave signal and said local oscillation light with this electrical signal, and is transmitted to an optical transmission line

[Claim 2] The lightwave signal transmitter [ equipped with a means to remove the noise resulting from fluctuation of said lightwave signal and said local oscillation light from the electrical signal acquired by the output of said optical-heterodyne-detection section ] according to claim 1.

[Claim 3] It is the lightwave-signal transmitter according to claim 2 with which said modulation input is baseband signaling, and an information signal and this information signal include a means to set off the fluctuation component which extracted said means to remove from this second

signal including the first signal to which the frequency modulation of said intermediate frequency signal was carried out by this information signal, and the second signal by which frequency modulation was carried out with said pilot signal including the pilot signal with which frequencies differ against the fluctuation component of said first signal.

[Claim 4] Said means to offset each other is the lightwave signal transmitter [ equipped with the means which carries out frequency mixing of the first band pass filter which said first signal passes, the second band pass filter which said second signal passes, and the output of this first band pass filter and the output of this second band pass filter ] according to claim 3.

[Claim 5] It is the lightwave signal transmitter according to claim 3 which is the signal which said information signal is a multi-channel amplitude modulation video signal by which frequency division multiplex was carried out, and said first signal bundled up this information signal, and carried out frequency modulation.

[Claim 6] For said information signal, said pilot signal is a lightwave signal transmitter according to claim 3 which is the subcarrier set as a frequency which is different in extent which can be classified with a band pass filter.

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**DETAILED DESCRIPTION**

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is used for optical communication. This invention is used for transmission of a broadband signal. This invention is suitable for using for transmission of a video signal. It is related with the technique of transforming the broadband electrical signal by which amplitude modulation was carried out especially into the electrical signal by which frequency modulation was carried out. This invention is suitable for using as a lightwave signal transmitter for cable television.

[0002]

[Description of the Prior Art] The frequency modulation of the electrical signal by which amplitude modulation was carried out is carried out, and the optical transmission method which changes this electrical signal into a lightwave signal, and is transmitted is learned. This conventional example is shown in drawing 9 . Drawing 9 is the whole optical transmission method block diagram of the conventional example. In the conventional example shown in drawing 9 , the multi-channel amplitude modulation (it is hereafter described as AM) video signal by which frequency division multiplex was carried out is collectively changed into a frequency modulation (it is hereafter described as FM) video signal, and optical transmission of the multi-channel video signal is carried out [a bibliography:1991 electronic communication link informatics meeting autumn convention, B-603, 4 - 64 pages, and a "pulse-ized FM package modulation analog light CATV distributing system"].

[0003] By inputting into a voltage controlled oscillator (it being hereafter described as VCO) the multi-channel AM video signal by which frequency division multiplex was carried out, the

electrical signal by which frequency modulation was carried out is outputted. Furthermore, the electrical signal with which it was uniformly operated orthopedically and the frequency modulation of the amplitude was carried out is outputted by inputting this electrical signal into a limiter. Direct modulation of the semiconductor laser is carried out with this electrical signal, and a lightwave signal is acquired. This lightwave signal is transmitted to a receiving side using an optical fiber.

[0004] Optical on-the-strength detection is carried out by the photodiode (PD) of a receiving side, and the lightwave signal transmitted with the optical fiber is again changed into an electrical signal. It restores to this electrical signal using SR flip-flop, the delay line, and a low pass filter, and the multiplex multi-channel amplitude modulation video signal with which frequency division of the origin was carried out is acquired by the receiving side.

[0005]

[Problem(s) to be Solved by the Invention] By such optical transmission method of the conventional example, like an optical fiber multi-channel image transmission system, when considering a broadband electrical signal as an input, a limit is in the frequency band which can be modulated by the band limit of the input frequency of VCO. In VCO shown in the conventional example, an input impedance becomes large in a RF and, as for the electrical signal which can be inputted, about 200MHz becomes a limitation. Therefore, the number of the image channels which can be transmitted to coincidence is about 20.

[0006] However, the 90MHz - 450MHz band where \*\*\*\* corresponds at about 30 channels is demanded of CATV current [ many ]. By the method using VCO shown in the conventional example, it cannot respond to this demand any longer.

[0007] This invention is carried out to such a background and aims at offering the lightwave signal transmitter which can transmit a broadband electrical signal by the optical frequency modulation. This invention aims at offering the lightwave signal transmitter which can transmit the video signal of many channels. This invention aims at offering the good lightwave signal transmitter of a signal quality. This invention aims at offering the equipment with which are satisfied of specification sufficient as a lightwave signal transmitter for cable television.

[0008]

[Means for Solving the Problem] This invention is characterized [ main ] by using an optical-heterodyne-detection technique for frequency modulation. Thereby, the frequency band which can be inputted as compared with the conventional equipment using VCO is broadband-ized sharply. Namely, the place by which this invention is a lightwave signal transmitter and it is characterized [ the ] The optical frequency modulation section which considers an electrical signal as a modulation input and outputs the lightwave signal by which frequency modulation was carried out, This lightwave signal and the optical frequency local oscillation section which outputs the local oscillation light of optical frequency which left only the intermediate frequency, The optical multiplexing section which multiplexes said lightwave signal and said local oscillation light, and the optical-heterodyne-detection section which inputs this lightwave signal it was multiplexed [ lightwave signal ] and outputs the electrical signal of an intermediate frequency equal to the difference of the optical frequency of said lightwave signal and said local oscillation light, It is in the place equipped with an optical transmitting means to output the lightwave signal which carries out intensity modulation of the light source with the electrical signal acquired by this optical-heterodyne-detection section output, and is transmitted to an optical transmission line. [0009] It is desirable to have a means to remove the noise resulting from fluctuation of said lightwave signal and said local oscillation light from the electrical signal acquired by said optical-heterodyne-detection section output. [0010] Said modulation input is baseband signaling and, as for an information signal and this information signal, it is desirable to include a means to set off the fluctuation component which extracted said means to remove from this second signal including the first signal to which the frequency modulation of said intermediate frequency signal was carried out by this information signal including the pilot signal with which frequencies differ, and the second signal by which frequency modulation was carried out with said pilot signal against the fluctuation component of said first signal.

[0011] As for said means to offset each other, it is desirable to have the means which carries

out frequency mixing of the first band pass filter which said first signal passes, the second band pass filter which said second signal passes, and the output of this first band pass filter and the output of this second band pass filter.

[0012] The electrical signal which removed by this the fluctuation component generated in process of the optical frequency modulation can be acquired.

[0013] Said information signal can be a multi-channel amplitude modulation video signal by which frequency division multiplex was carried out, and said first signal can be a signal which carried out the frequency modulation of this information signal collectively.

[0014] Said pilot signal can be the subcarrier set as the frequency from which said information signal differs in extent which can be classified with a band pass filter.

[0015]

[Function] An electrical signal is considered as a modulation input, the lightwave signal by which frequency modulation was carried out is outputted, and the local oscillation light of different optical frequency from this lightwave signal is multiplexed to this lightwave signal by which frequency modulation was carried out. By outputting the electrical signal of a frequency equal to the difference of the optical frequency of these two lightwave signals from these two lightwave signals it was multiplexed [ lightwave signals ], the electrical signal by which amplitude modulation was carried out is transformed into the electrical signal by which frequency modulation was carried out. As an electric light conversion means, although semiconductor laser is used, since semiconductor laser can perform electric light conversion even if the electrical signal to input is a RF to about several GHz, it can realize large broadband-ization as compared with the electric means of VCO and others, for example. A frequency equal to the difference of the optical frequency of two lightwave signals is a frequency which an electrical signal can treat.

[0016] Furthermore, the electrical signal of the broadband where the frequency modulation of the high signal quality was carried out can be acquired by removing the noise resulting from fluctuation of the lightwave signal by which frequency modulation was carried out, and local oscillation light from this electrical signal.

[0017] Said modulation input is baseband signaling and, as for the first signal to which the frequency modulation of the electrical signal with which an information signal and this information signal are outputted by optical heterodyne detection including the pilot signal with which frequencies differ was carried out by this information signal, and this first signal by which frequency modulation was carried out with said pilot signal, the frequency includes the second different signal in that signal. At this time, it is good to remove the noise included in an electrical signal by offsetting the fluctuation component of the first signal by the fluctuation component extracted from this second signal.

[0018] The first signal and second signal can be separated and taken out in offset of fluctuation using a band pass filter, and it can carry out to it by carrying out frequency mixing of these.

[0019] An information signal is a multi-channel AM video signal by which frequency division multiplex was carried out, for example, and, as for the first signal, it is desirable that it is the signal which carried out the frequency modulation of this information signal collectively. This invention can input and carry out the frequency modulation of the electrical signal of such a broadband.

[0020] As for a pilot signal, it is desirable for an information signal to be the subcarrier of a different frequency. Since a pilot signal is a signal for acquiring the fluctuation used for offset, it is good to use the subcarrier of a different frequency from an information signal so that it can dissociate with an information signal.

[0021]

[Example] The configuration of this invention example is explained with reference to drawing 1 . Drawing 1 is the whole this invention example block diagram.

[0022] The place by which this invention is a lightwave signal transmitter and it is characterized [ the ] The optical frequency modulation section 1 which considers an electrical signal as a modulation input and outputs the lightwave signal by which frequency modulation was carried out, This lightwave signal and the optical frequency local oscillation section 2 which outputs the local oscillation light of optical frequency which left only the intermediate frequency, The optical

multiplexing section 3 which multiplexes said lightwave signal and said local oscillation light, and the optical-heterodyne-detection section 4 which inputs this lightwave signal it was multiplexed [ lightwave signal ] and outputs the electrical signal of an intermediate frequency equal to the difference of the optical frequency of said lightwave signal and said local oscillation light, The package FM video-signal frequency stabilization section 5 as a means which removes the noise resulting from fluctuation of said lightwave signal and said local oscillation light from this electrical signal, It is in the place equipped with the package FM video-signal light transmitting section 6 as an optical transmitting means to output the lightwave signal which carries out intensity modulation of the light source with the electrical signal from this package FM video-signal frequency stabilization section 5, and is transmitted to an optical transmission line.

[0023] Next, actuation of this invention example is explained. First, the optical frequency modulation section 1 is explained with reference to drawing 2 . Drawing 2 is the block block diagram of the optical frequency modulation section 1. Multiplex [ of the pilot signal ] is carried out by frequency division multiplex, with this multi-channel amplitude modulation video signal and pilot signal by which frequency division multiplex was carried out, the optical frequency modulation of the single mode laser 10 for an optical frequency modulation is carried out, and a lightwave signal f1 is outputted to the multi-channel AM video signal which is inputted and by which frequency division multiplex was carried out. In this invention example, a multi-channel AM video signal is a 90MHz - 450MHz signal by which Frequency Division Multiplexing was carried out. The 2.1GHz subcarrier was used as a pilot signal. The single mode laser 10 for an optical frequency modulation is the lightwave signal of the wavelength the band of 1.5 micrometers of 193006.1 GHz. As a lightwave signal f1 is shown in drawing 2 , the field of a video signal exists in bilateral symmetry focusing on 193006.1 GHz, and the field of a pilot signal exists in the both ends.

[0024] Next, the optical frequency local oscillation section 2, the optical multiplexing section 3, and the optical-heterodyne-detection section 4 are explained with reference to drawing 3 thru/or drawing 5 . Drawing 3 is the block block diagram of the optical frequency local oscillation section 2. Drawing 4 is the block block diagram of the optical multiplexing section 3. Drawing 5 is the block block diagram of the optical-heterodyne-detection section 4. It is multiplexed in the local oscillation lightwave signal of the optical frequency f2 outputted from the optical frequency local oscillation section 2 so that a polarization condition may become the same in the optical coupler 14 of the optical multiplexing machine 3 shown in drawing 4 with the lightwave signal f1 outputted from the optical frequency modulation section 1. In this invention example, the lightwave signal f2 was made into the 193000GHz lightwave signal, as shown in drawing 3 .

[0025] The lightwave signal it was multiplexed [ lightwave signal ] is inputted into the optical-heterodyne-detection section 4 shown in drawing 5 , and detection on the strength [ optical ] is performed by the photodiode 30, and it is changed into a frequency ( $f_2 - f_1$ ), i.e., the electrical signal which is  $193006.1\text{GHz} - 193000\text{GHz} = 6.1\text{GHz}$ . This frequency ( $f_2 - f_1 = 6.1\text{GHz}$ ) is a frequency [ treatment / a frequency ] as an electric frequency.

[0026] Next, the package FM video-signal frequency stabilization section 5 is explained with reference to drawing 6 . Drawing 6 is the block block diagram of the package FM video-signal frequency stabilization section 5. The pilot signal shown in drawing 6 (d) is extracted from the electrical signal of the frequency ( $f_2 - f_1 = 6.1\text{GHz}$ ) outputted from the optical-heterodyne-detection section 4 shown in drawing 6 (a) using a band pass filter 24, and the package FM video signal shown in drawing 6 (b) is extracted using a band pass filter 22. Variable attenuators 25 and 26 adjust two electrical signals extracted using these two band pass filters 22 and 24 on desired level, it inputs into the frequency-mixing machine 20, and the electrical signal which is shown in drawing 6 (c) and by which frequency mixing was carried out is outputted. Thereby, although the optical frequency of the single mode laser 10 for an optical frequency modulation and the single mode laser 12 for local oscillation swings by disturbance and others, it can offset that fluctuation in this package FM video-signal frequency stabilization section 5, respectively.

[0027] Here, actuation of the package FM video-signal frequency stabilization section 5 is further explained to a detail. Drawing 7 is drawing showing the signal state of each part. Drawing 7 (A) shows the condition of AM video signal inputted into the optical frequency modulation

section 1, and the pilot signal of optical frequency  $f_p$ . As mentioned above, the frequency band of AM video signal is 90MHz – 450MHz, and the frequency of a pilot signal is 2.1GHz. Although the electrical signal shown in this drawing 7 (A) is changed into the lightwave signal in which frequency modulation was carried out by the optical frequency modulation section 1, that lightwave signal will be in the condition which shows in drawing 7 (B) by the fluctuation which the single mode laser 10 for an optical frequency modulation of the optical frequency modulation section 1 has, or fluctuation by the disturbance of temperature fluctuation and others.  $\Delta f_1$  is a fluctuation component here. As mentioned above, the frequency  $f_1$  of a lightwave signal is 193006.1 GHz, and the frequency ( $f_1 + f_p$ ) of an optical pilot signal is 193008.2 GHz. Drawing 7 (C) shows the condition of the local oscillation light of the frequency  $f_2$  outputted from the optical frequency local oscillation section 2.  $\Delta f_2$  is a fluctuation component here. As mentioned above, the frequency  $f_2$  of local oscillation light is 193000GHz. Although drawing 7 (D) is the electrical signal of the frequency ( $f_1 - f_2$ ) outputted from the optical-heterodyne-detection section 4, the fluctuation included in a lightwave signal is changed into an electrical signal as it is.  $\Delta f (= \Delta f_1 + \Delta f_2)$  is a fluctuation component here. Drawing 7 (E) is the package FM video signal separated with the band pass filter 22 of the package FM video-signal frequency stabilization section 5. Drawing 7 (F) is the pilot signal separated with the band pass filter 24 of the package FM video-signal frequency stabilization section 5.  $\Delta f (= \Delta f_1 + \Delta f_2)$  is a fluctuation component here. By carrying out frequency mixing of the package FM video signal shown in the pilot signal shown in this drawing 7 (F), and drawing 7 (E), the package FM video signal with which the fluctuation component as shown in drawing 7 (G) was offset can be acquired. Furthermore, as for this package FM video signal, the amplitude is orthopedically operated by the limiter 11.

[0028] Next, the package FM video-signal light transmitting section 6, the optical-fiber-transmission way 9, the package FM video-signal receive section 7, and the package FM video-signal recovery section 8 are explained with reference to drawing 8. Drawing 8 is the block diagram of the package FM video-signal light transmitting section 6, the optical-fiber-transmission way 9, the package FM video-signal receive section 7, and the package FM video-signal recovery section 8. In the package FM video-signal light transmitting section 6, with the electrical signal outputted from the package FM video-signal frequency stabilization section 5, intensity modulation of the semiconductor laser 40 for transmission is carried out, and the optical output is inputted into the optical-fiber-transmission way 9.

[0029] The lightwave signal outputted from the package FM video-signal light transmitting section 6 by the optical-fiber-transmission way 9 is transmitted to the package FM video-signal light receive section 7. In the package FM video-signal light receive section 7, optical on-the-strength detection of the received lightwave signal is carried out with a photodiode 50, and the detected electrical signal is outputted.

[0030] In the package FM video-signal recovery section 8, the detected electrical signal is inputted into a delay detector circuit, it restores to the electrical signal by which frequency modulation was carried out, and the same signal as the multi-channel amplitude modulation video signal which was inputted into the optical frequency modulation section 1 and by which frequency division multiplex was carried out is outputted as a recovery signal.

[0031] Although this invention example explained the multi-channel AM video signal by which frequency division multiplex was carried out as a lightwave signal transmitter considered as an input, it can explain an analog or an electrical signal [ broadband / digital ] similarly as an input except a video signal.

[0032]

[Effect of the Invention] As explained above, according to this invention, the lightwave signal transmitter which can input a broadband electrical signal is realizable. Thereby, the video signal of many channels can be transmitted. Furthermore, the good lightwave signal transmitter of a signal quality is realizable. This invention is especially used for the lightwave signal transmitter for cable television, and is effective.

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**DESCRIPTION OF DRAWINGS**

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[Brief Description of the Drawings]

[Drawing 1] The whole this invention example block diagram.

[Drawing 2] The block block diagram of the optical frequency modulation section.

[Drawing 3] The block block diagram of the optical frequency local oscillation section.

[Drawing 4] The block block diagram of the optical multiplexing section.

[Drawing 5] The block block diagram of the optical-heterodyne-detection section.

[Drawing 6] The block block diagram of the package FM video-signal frequency stabilization section.

[Drawing 7] Drawing showing the signal state of each part.

[Drawing 8] The block block diagram of the package FM video-signal light transmitting section, an optical-fiber-transmission way, a package FM video-signal receive section, and the package FM video-signal recovery section.

[Drawing 9] The whole optical transmission method block diagram of the conventional example.

[Description of Notations]

- 1 Optical Frequency Modulation Section
- 2 Optical Frequency Local Oscillation Section
- 3 Optical Multiplexing Section
- 4 Optical-Heterodyne-Detection Section
- 5 Package FM Video-Signal Frequency Stabilization Section
- 6 Package FM Video-Signal Light Transmitting Section
- 7 Package FM Video-Signal Light Receive Section
- 8 Package FM Video-Signal Recovery Section
- 9 Optical-Fiber-Transmission Way
- 10 Single Mode Laser for Optical Frequency Modulation
- 11 Limiter
- 12 Single Mode Laser for Local Oscillation
- 14 Optical Coupler
- 20 Frequency-Mixing Machine
- 22 24 Band pass filter
- 25 26 Variable attenuator
- 30 50 Photodiode
- 40 Semiconductor Laser for Transmission

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[Translation done.]

**\* NOTICES \***

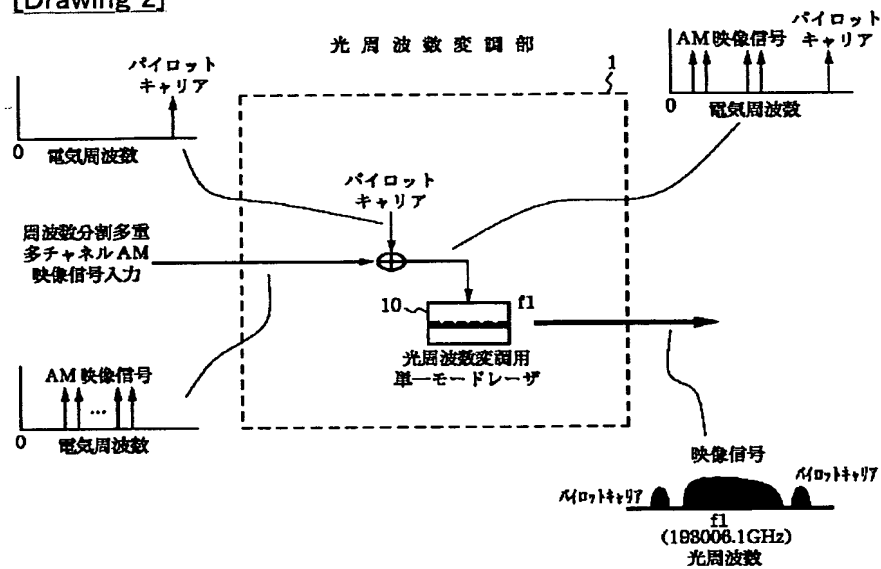
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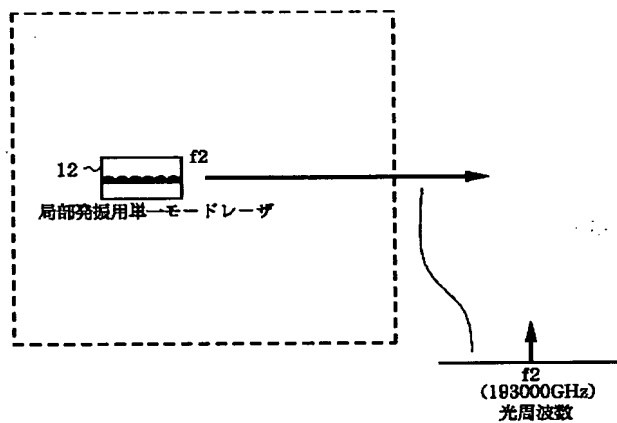
## DRAWINGS

[Drawing 2]

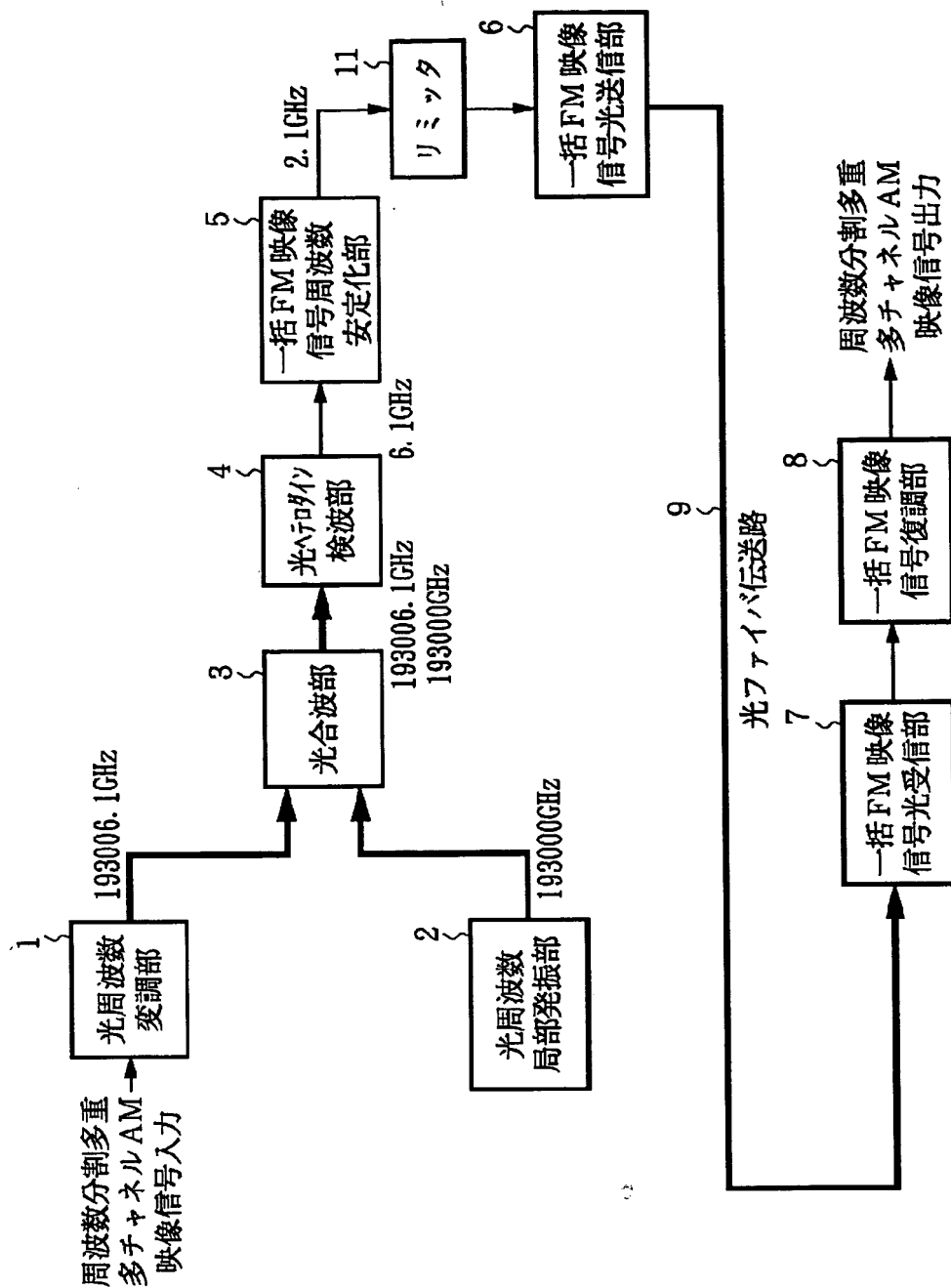


[Drawing 3]

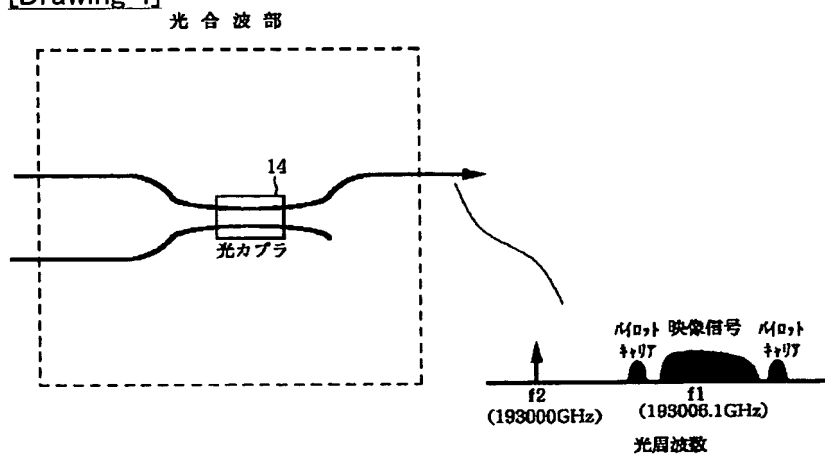
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[Drawing 1]

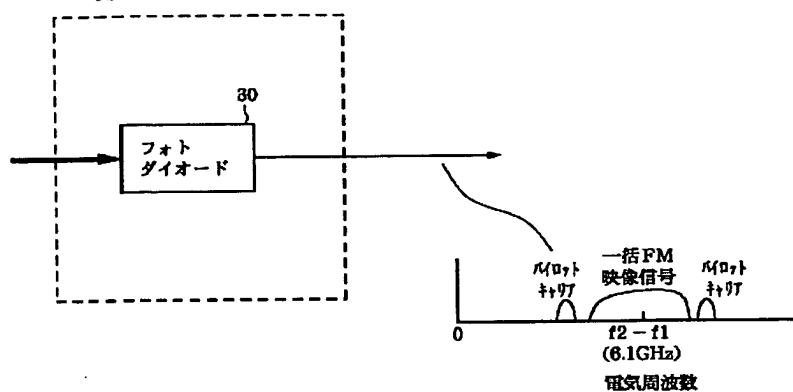


[Drawing 4]

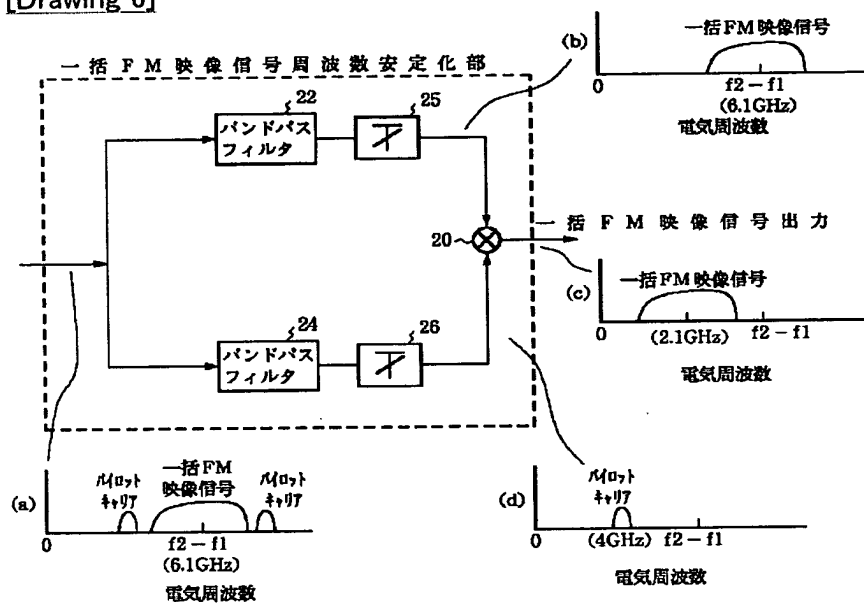


[Drawing 5]

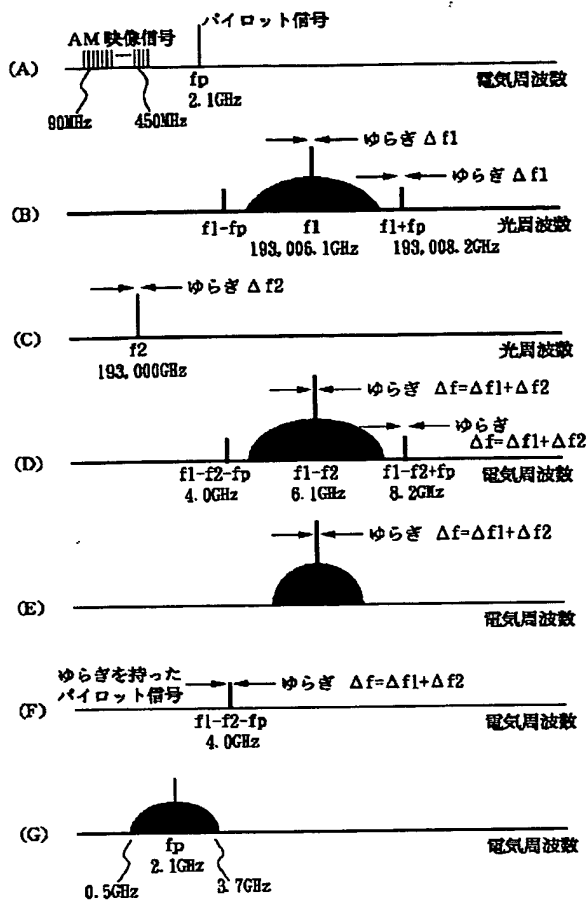
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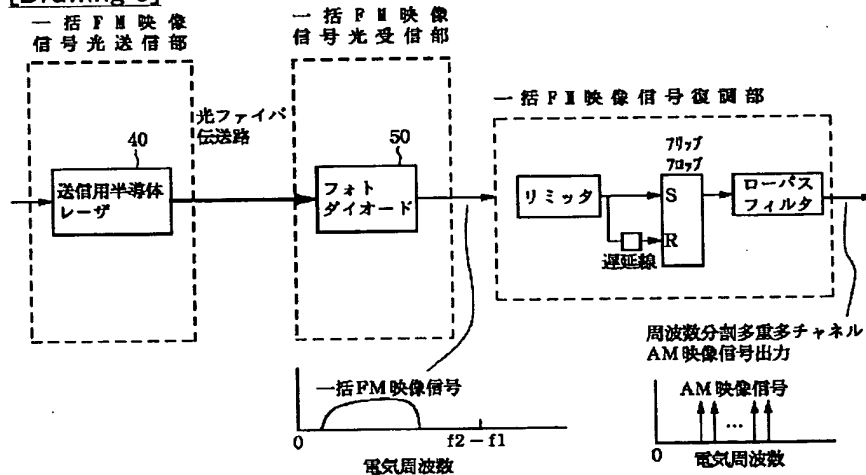
[Drawing 6]



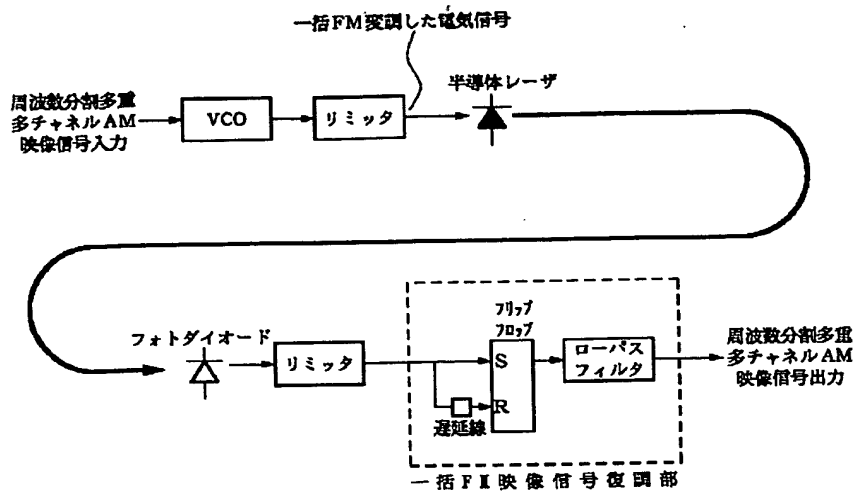
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]

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(12) 特 許 公 報 (B 2)

(11) 特許番号

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	10/00		H 0 4 N 7/22	
	10/04		H 0 4 B 9/00	C
	10/06			L
	10/142			

請求項の数6(全 9 頁) 最終頁に続く

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最終頁に続く

(54) 【発明の名称】 光信号送信機

1

(57) 【特許請求の範囲】

【請求項1】 電気信号を変調入力とし周波数変調された光信号を出力する光周波数変調部と、  
この光信号と中間周波数だけ離れた光周波数の局部発振光を出力する光周波数局部発振部と、  
前記光信号と前記局部発振光とを合波する光合波部と、  
この合波された光信号を入力し前記光信号と前記局部発振光との光周波数の差に等しい中間周波数の電気信号を出力する光ヘテロダイン検波部と、  
この電気信号により光源を強度変調し光伝送路に送信する光信号を出力する光送信手段とを備えたことを特徴とする光信号送信機。

【請求項2】 前記光ヘテロダイン検波部の出力に得られる電気信号から前記光信号および前記局部発振光のゆらぎに起因する雑音を除去する手段を備えた請求項1記

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載の光信号送信機。

【請求項3】 前記変調入力はベースバンド信号であり情報信号とこの情報信号とは周波数の異なるパイロット信号とを含み、前記中間周波数信号はこの情報信号により周波数変調された第一の信号と前記パイロット信号により周波数変調された第二の信号とを含み、  
前記除去する手段は、この第二の信号から抽出したゆらぎ成分を前記第一の信号のゆらぎ成分と相殺する手段を含む請求項2記載の光信号送信機。

【請求項4】 前記相殺する手段は、前記第一の信号が通過する第一の帯域濾波器と、前記第二の信号が通過する第二の帯域濾波器と、この第一の帯域濾波器の出力とこの第二の帯域濾波器の出力とを周波数混合する手段とを備えた請求項3記載の光信号送信機。

【請求項5】 前記情報信号は、周波数分割多重された

多チャネル振幅変調映像信号であり、前記第一の信号は、この情報信号を一括して周波数変調した信号である請求項3記載の光信号送信機。

【請求項6】 前記パイロット信号は、前記情報信号とは帯域濾波器で分別できる程度に異なる周波数に設定された搬送波である請求項3記載の光信号送信機。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は光通信に利用する。本発明は広帯域信号の伝送に利用する。本発明は映像信号の伝送に利用するに適する。特に、振幅変調された広帯域電気信号を周波数変調された電気信号に変換する技術に関する。本発明は、ケーブルテレビジョン用の光信号送信機として利用するに適する。

【0002】

【従来の技術】振幅変調された電気信号を周波数変調し、この電気信号を光信号に変換して送信する光伝送方式が知られている。この従来例を図9に示す。図9は従来例の光伝送方式の全体構成図である。図9に示す従来例では、周波数分割多重された多チャネル振幅変調（以下、AMと記す）映像信号を一括して周波数変調（以下、FMと記す）映像信号に変換し、多チャネル映像信号を光伝送する〔参考文献：1991年電子通信情報学会秋季大会、B-603、4-64ページ、「パルス化FM一括変調アナログ光CATV分配方式」〕。

【0003】周波数分割多重された多チャネルAM映像信号を電圧制御発振器（以下、VCOと記す）に入力することにより、周波数変調された電気信号が出力される。さらに、この電気信号をリミッタに入力することにより、振幅が一定に整形され周波数変調された電気信号が出力される。この電気信号により半導体レーザを直接変調して光信号を得る。この光信号は光ファイバを用いて受信側に伝送される。

【0004】光ファイバにより伝送された光信号は、受信側のフォトダイオード（PD）により光強度検波され再び電気信号に変換される。この電気信号をSRフリップフロップ、遅延線、ローパスフィルタを用いて復調し、元の周波数分割された多重多チャネル振幅変調映像信号が受信側で得られる。

【0005】

【発明が解決しようとする課題】このような従来例の光伝送方式では、光ファイバ多チャネル映像伝送システムのように、広帯域な電気信号を入力とする場合に、VCOの入力周波数の帯域制限により変調することができる周波数帯域に限度がある。従来例で示したVCOでは、入力できる電気信号は、入力インピーダンスが高周波において大きくなり、およそ200MHzが限界となる。したがって、同時に伝送できる映像チャネルの数は20チャネル程度である。

【0006】しかし、現在、多くのCATVにおいて

は、およそ30チャネル分に相当する90MHz～450MHzの帯域が要求されている。従来例で示したVCOを用いる方式では、もはやこの要求に対応することはできない。

【0007】本発明は、このような背景に行われたものであり、広帯域な電気信号を光周波数変調により伝送することができる光信号送信機を提供することを目的とする。本発明は、多チャネルの映像信号を送信することができる光信号送信機を提供することを目的とする。本発明は、信号品質のよい光信号送信機を提供することを目的とする。本発明は、ケーブルテレビジョン用の光信号送信機として十分な規格を満足する装置を提供することを目的とする。

【0008】

【課題を解決するための手段】本発明は、周波数変調に光ヘテロダイン検波技術を用いることを主要な特徴とする。これにより、VCOを用いた従来の装置と比較して入力することができる周波数帯域が大幅に広帯域化される。すなわち本発明は、光信号送信機であり、その特徴とするところは、電気信号を変調入力とし周波数変調された光信号を出力する光周波数変調部と、この光信号と中間周波数だけ離れた光周波数の局部発振光を出力する光周波数局部発振部と、前記光信号と前記局部発振光とを合波する光合波部と、この合波された光信号を入力し前記光信号と前記局部発振光との光周波数の差に等しい中間周波数の電気信号を出力する光ヘテロダイン検波部と、この光ヘテロダイン検波部出力に得られる電気信号により光源を強度変調し光伝送路に送信する光信号を出力する光送信手段とを備えたところにある。

【0009】前記光ヘテロダイン検波部出力に得られる電気信号から前記光信号および前記局部発振光のゆらぎに起因する雑音を除去する手段を備えることが望ましい。

【0010】前記変調入力にはベースバンド信号であり情報信号とこの情報信号とは周波数の異なるパイロット信号とを含み、前記中間周波数信号はこの情報信号により周波数変調された第一の信号と前記パイロット信号により周波数変調された第二の信号とを含み、前記除去する手段は、この第二の信号から抽出したゆらぎ成分を前記第一の信号のゆらぎ成分と相殺する手段を含むことが望ましい。

【0011】前記相殺する手段は、前記第一の信号が通過する第一の帯域濾波器と、前記第二の信号が通過する第二の帯域濾波器と、この第一の帯域濾波器の出力とこの第二の帯域濾波器の出力とを周波数混合する手段とを備えることが望ましい。

【0012】これにより、光周波数変調の過程で発生したゆらぎ成分を除去した電気信号を得ることができる。

【0013】前記情報信号は、周波数分割多重された多チャネル振幅変調映像信号であり、前記第一の信号は、

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この情報信号を一括して周波数変調した信号であることができる。

【0014】前記パイロット信号は、前記情報信号とは帯域濾波器で分別できる程度に異なる周波数に設定された搬送波であることができる。

【0015】

【作用】電気信号を変調入力とし周波数変調された光信号を出力し、この光信号とは異なる光周波数の局部発振光をこの周波数変調された光信号に合波する。この合波された二つの光信号からこの二つの光信号の光周波数の差に等しい周波数の電気信号を出力することにより、振幅変調された電気信号が周波数変調された電気信号に変換される。電気光変換手段としては、例えば、半導体レーザを用いるが、半導体レーザは、入力する電気信号が数GHzくらいまでの高周波であっても、電気光変換を行うことができるので、VCOその他の電気的手段と比較すると大幅な広帯域化を実現することができる。二つの光信号の光周波数の差に等しい周波数は電気信号が扱うことのできる周波数である。

【0016】さらに、周波数変調された光信号および局部発振光のゆらぎに起因する雑音をこの電気信号から除去することにより、高い信号品質の周波数変調された広帯域の電気信号を得ることができる。

【0017】前記変調入力はベースバンド信号であり、その信号には情報信号とこの情報信号とは周波数の異なるパイロット信号とを含み、光ヘテロダイン検波により出力される電気信号は、この情報信号により周波数変調された第一の信号と前記パイロット信号により周波数変調されたこの第一の信号とは周波数が異なる第二の信号とを含んでいる。このとき、この第二の信号から抽出したゆらぎ成分により第一の信号のゆらぎ成分を相殺することにより電気信号に含まれる雑音を除去することがよい。

【0018】ゆらぎの相殺には、例えば、帯域濾波器を用いて第一の信号と第二の信号とを分離して取り出し、これらを周波数混合することにより行うことができる。

【0019】情報信号は、例えば、周波数分割多重された多チャネルAM映像信号であり、第一の信号は、この情報信号を一括して周波数変調した信号であることが望ましい。本発明は、このような広帯域の電気信号を入力して周波数変調することができる。

【0020】パイロット信号は、情報信号とは異なる周波数の搬送波であることが望ましい。パイロット信号は、相殺に用いるゆらぎを得るための信号であるから、情報信号と分離できるように、情報信号とは異なる周波数の搬送波を用いることがよい。

【0021】

【実施例】本発明実施例の構成を図1を参照して説明する。図1は本発明実施例の全体構成図である。

【0022】本発明は光信号送信機であり、その特徴と

するところは、電気信号を変調入力とし周波数変調された光信号を出力する光周波数変調部1と、この光信号と中間周波数だけ離れた光周波数の局部発振光を出力する光周波数局部発振部2と、前記光信号と前記局部発振光とを合波する光合波部3と、この合波された光信号を入力し前記光信号と前記局部発振光との光周波数の差に等しい中間周波数の電気信号を出力する光ヘテロダイン検波部4と、この電気信号から前記光信号および前記局部発振光のゆらぎに起因する雑音を除去する手段としての一括FM映像信号周波数安定化部5と、この一括FM映像信号周波数安定化部5からの電気信号により光源を強度変調し光伝送路に送信する光信号を出力する光送信手段としての一括FM映像信号光送信部6とを備えたところにある。

【0023】次に、本発明実施例の動作を説明する。まず、光周波数変調部1を図2を参照して説明する。図2は光周波数変調部1のブロック構成図である。入力される周波数分割多重された多チャネルAM映像信号に、パイロット信号を周波数分割多重により多重し、この周波数分割多重された多チャネル振幅変調映像信号とパイロット信号により、光周波数変調用単一モードレーザ10を光周波数変調し光信号f1を出力する。本発明実施例では、多チャネルAM映像信号は90MHz～450MHzの周波数分割多重された信号である。パイロット信号としては、2.1GHzの搬送波を用いた。光周波数変調用単一モードレーザ10は193006.1GHzの波長1.5μm帯の光信号である。光信号f1は、図2に示すように、193006.1GHzを中心に左右対称に映像信号の領域が存在し、その両端にパイロット信号の領域が存在する。

【0024】次に、光周波数局部発振部2、光合波部3および光ヘテロダイン検波部4を図3ないし図5を参照して説明する。図3は光周波数局部発振部2のブロック構成図である。図4は光合波部3のブロック構成図である。図5は光ヘテロダイン検波部4のブロック構成図である。光周波数局部発振部2から出力される光周波数f2の局部発振光信号は、光周波数変調部1から出力される光信号f1とともに、図4に示す光合波器3の光カプラ14において偏波状態が同じになるように合波される。本発明実施例では、光信号f2は、図3に示すように、193000GHzの光信号とした。

【0025】合波された光信号は、図5に示す光ヘテロダイン検波部4に入力されて、フォトダイオード30により光強度検波が行われ周波数(f2-f1)、すなわち、

$$193006.1\text{GHz} - 193000\text{GHz} = 6.1\text{GHz}$$

の電気信号に変換される。この周波数(f2-f1=6.1GHz)は電気周波数として扱いが可能な周波数である。



【0026】次に、一括FM映像信号周波数安定化部5を図6を参照して説明する。図6は一括FM映像信号周波数安定化部5のブロック構成図である。図6(a)に示す光ヘテロダイン検波部4から出力された周波数( $f_2 - f_1 = 6.1 \text{ GHz}$ )の電気信号から帯域濾波器24を用いて、図6(d)に示すパイロット信号を抽出し、帯域濾波器22を用いて、図6(b)に示す一括FM映像信号を抽出する。これら二つの帯域濾波器22、24を用いて抽出した二つの電気信号をレベル調整器25、26により所望のレベルに調整して周波数混合器20に入力し、図6(c)に示す周波数混合された電気信号を出力する。これにより、光周波数変調用単一モードレーザ10と局部発振用単一モードレーザ12の光周波数がそれぞれ、外乱その他によりゆらいでも、この一括FM映像信号周波数安定化部5において、そのゆらぎを相殺することができる。

【0027】ここで、一括FM映像信号周波数安定化部5の動作をさらに詳細に説明する。図7は各部の信号状態を示す図である。図7(A)は、光周波数変調部1に入力されるAM映像信号および光周波数 $f_p$ のパイロット信号の状態を示している。前述したように、AM映像信号の周波数帯域は90MHz～450MHzであり、パイロット信号の周波数は2.1GHzである。この図7(A)に示した電気信号は、光周波数変調部1により周波数変調された光信号に変換されるが、光周波数変調部1の光周波数変調用単一モードレーザ10の有するゆらぎ、あるいは温度変動その他の外乱によるゆらぎにより、その光信号は、図7(B)に示す状態になる。ここで $\Delta f_1$ はゆらぎ成分である。前述したように、光信号の周波数 $f_1$ は193006.1GHzであり、光パイロット信号の周波数( $f_1 + f_p$ )は193008.2GHzである。図7(C)は、光周波数局部発振部2から出力される周波数 $f_2$ の局部発振光の状態を示している。ここで $\Delta f_2$ はゆらぎ成分である。前述したように、局部発振光の周波数 $f_2$ は193000GHzである。図7(D)は、光ヘテロダイン検波部4から出力される周波数( $f_1 - f_2$ )の電気信号であるが、光信号に含まれるゆらぎはそのまま電気信号に変換される。ここで $\Delta f (= \Delta f_1 + \Delta f_2)$ はゆらぎ成分である。図7(E)は、一括FM映像信号周波数安定化部5の帯域濾波器22により分離された一括FM映像信号である。図7(F)は、一括FM映像信号周波数安定化部5の帯域濾波器24により分離されたパイロット信号である。ここで $\Delta f (= \Delta f_1 + \Delta f_2)$ はゆらぎ成分である。この図7(F)に示すパイロット信号と図7(E)に示す一括FM映像信号とを周波数混合することにより、図7(G)に示すようなゆらぎ成分が相殺された一括FM映像信号を得ることができる。さらに、この一括FM映像信号は、リミッタ11により振幅が整形される。

【0028】次に、一括FM映像信号光送信部6、光フ

ァイバ伝送路9、一括FM映像信号受信部7および一括FM映像信号復調部8を図8を参照して説明する。図8は一括FM映像信号光送信部6、光ファイバ伝送路9、一括FM映像信号受信部7および一括FM映像信号復調部8のブロック構成図である。一括FM映像信号光送信部6では、一括FM映像信号周波数安定化部5から出力される電気信号により、送信用半導体レーザ40を強度変調し、その光出力を光ファイバ伝送路9に入力する。

【0029】光ファイバ伝送路9により、一括FM映像信号光送信部6から出力された光信号を一括FM映像信号光受信部7まで伝送する。一括FM映像信号光受信部7においては、受信した光信号をフォトダイオード50により光強度検波し、検波された電気信号を出力する。

【0030】一括FM映像信号復調部8においては、検波された電気信号を遅延検波回路に入力し、周波数変調された電気信号の復調を行い、光周波数変調部1に入力された周波数分割多重された多チャネル振幅変調映像信号と同一の信号を復調信号として出力する。

【0031】本発明実施例は、周波数分割多重された多チャネルAM映像信号を入力とする光信号送信機として説明したが、映像信号以外でも、アナログまたはデジタルの広帯域な電気信号を入力として同様に説明することができる。

【0032】

【発明の効果】以上説明したように、本発明によれば、広帯域な電気信号を入力することができる光信号送信機を実現することができる。これにより、多チャネルの映像信号を送信することができる。さらに、信号品質のよい光信号送信機を実現することができる。本発明は、ケーブルテレビジョン用の光信号送信機に利用して特に有効である。

【図面の簡単な説明】

【図1】本発明実施例の全体構成図。

【図2】光周波数変調部のブロック構成図。

【図3】光周波数局部発振部のブロック構成図。

【図4】光合波部のブロック構成図。

【図5】光ヘテロダイン検波部のブロック構成図。

【図6】一括FM映像信号周波数安定化部のブロック構成図。

【図7】各部の信号状態を示す図。

【図8】一括FM映像信号光送信部、光ファイバ伝送路、一括FM映像信号受信部および一括FM映像信号復調部のブロック構成図。

【図9】従来例の光伝送方式の全体構成図。

【符号の説明】

1 光周波数変調部

2 光周波数局部発振部

3 光合波部

4 光ヘテロダイン検波部

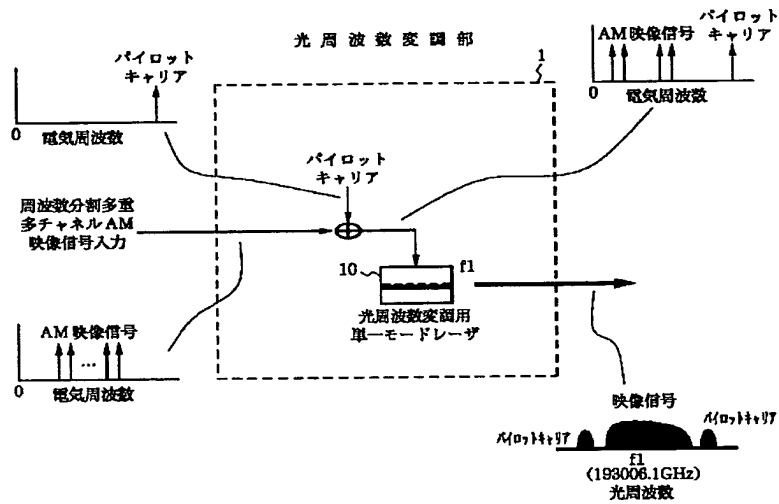
5 一括FM映像信号周波数安定化部

- 6 一括FM映像信号光送信部
- 7 一括FM映像信号光受信部
- 8 一括FM映像信号復調部
- 9 光ファイバ伝送路
- 10 光周波数変調用単一モードレーザ
- 11 リミッタ
- 12 局部発振用単一モードレーザ

- \* 14 光カプラ
- 20 周波数混合器
- 22、24 帯域濾波器
- 25、26 レベル調整器
- 30、50 フォトダイオード
- 40 送信用半導体レーザ

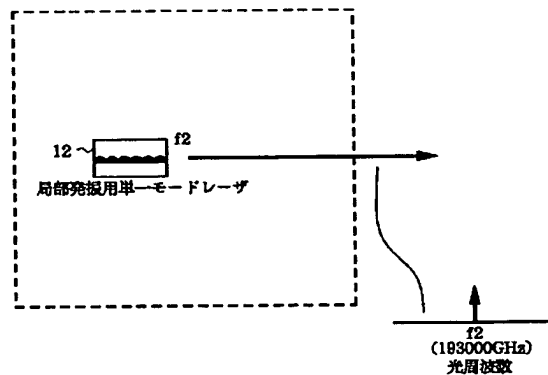
\*

【図2】



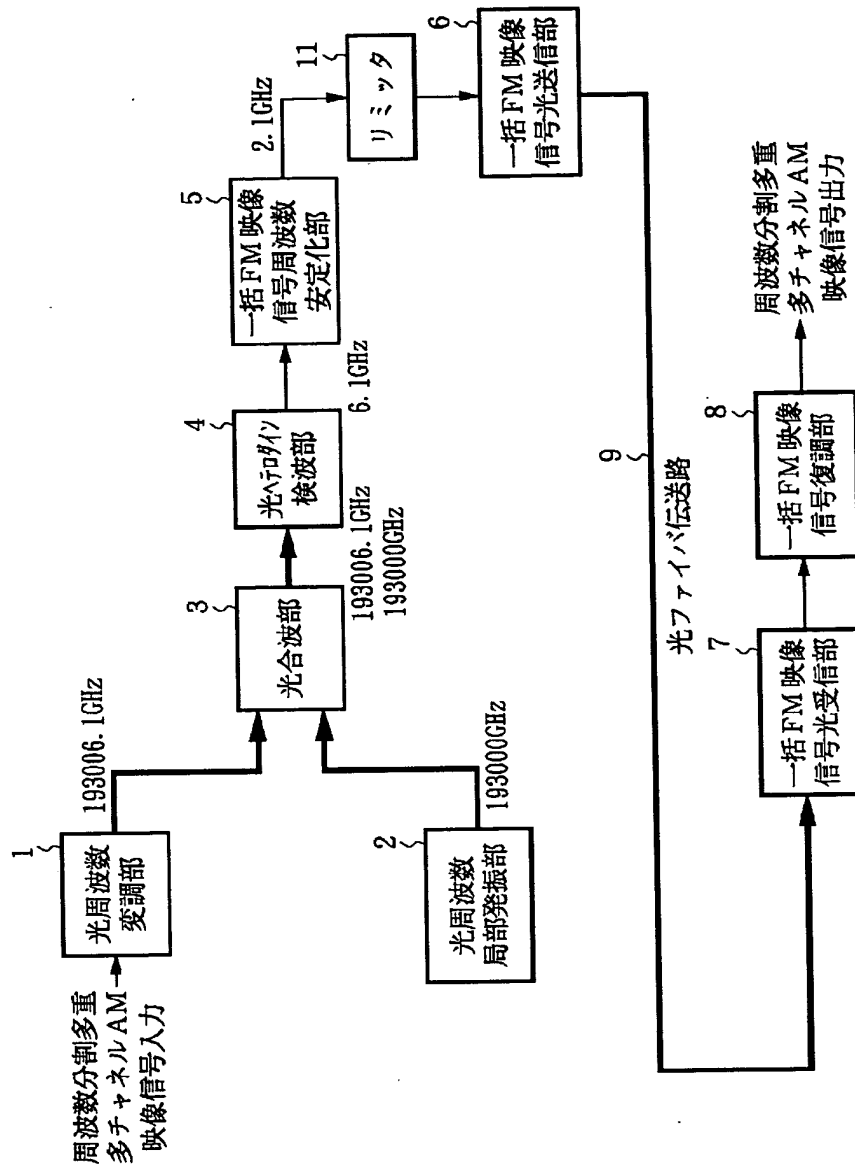
【図3】

光周波数局部発振部

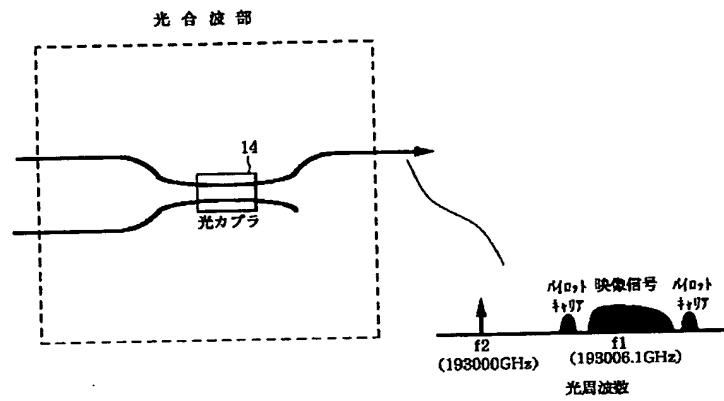


(6)

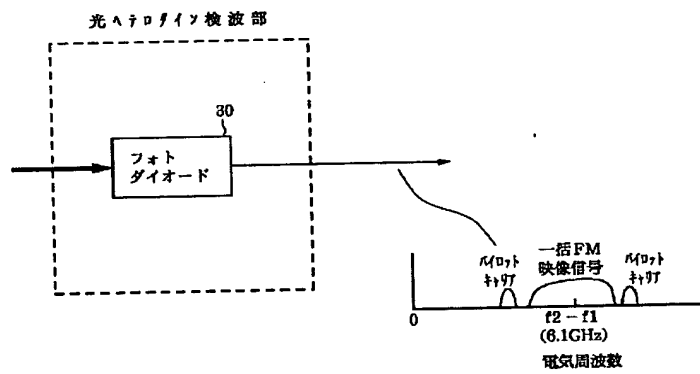
【図1】



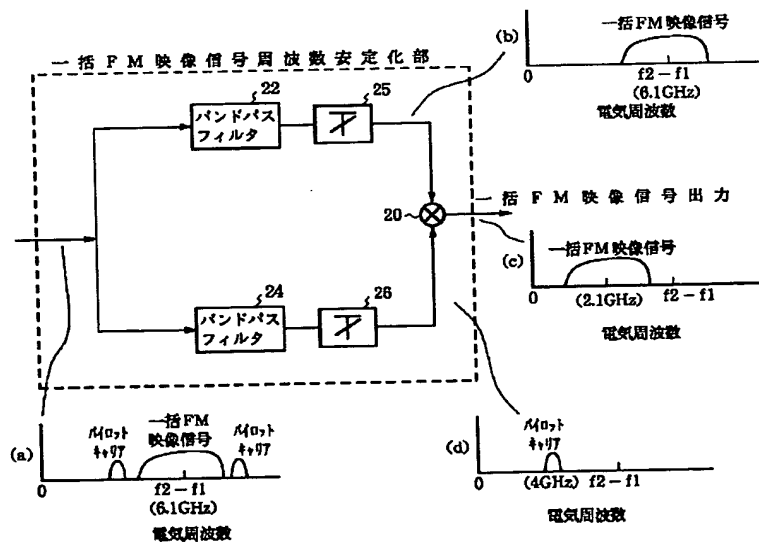
【図4】



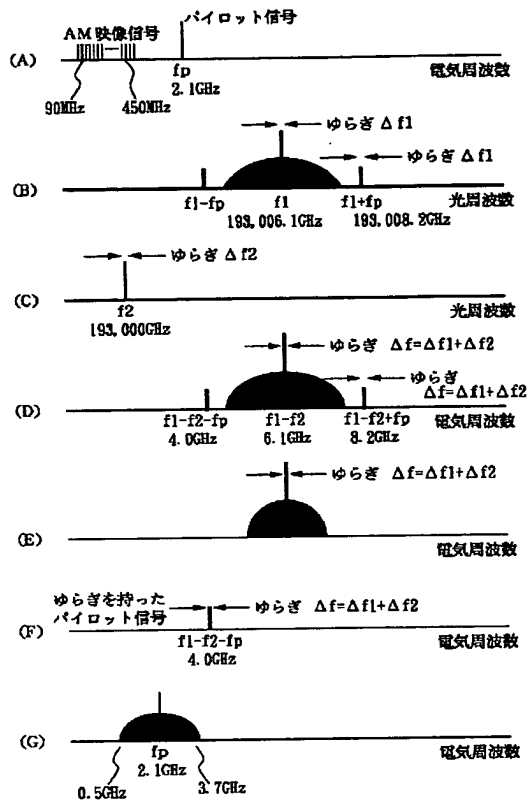
【図5】



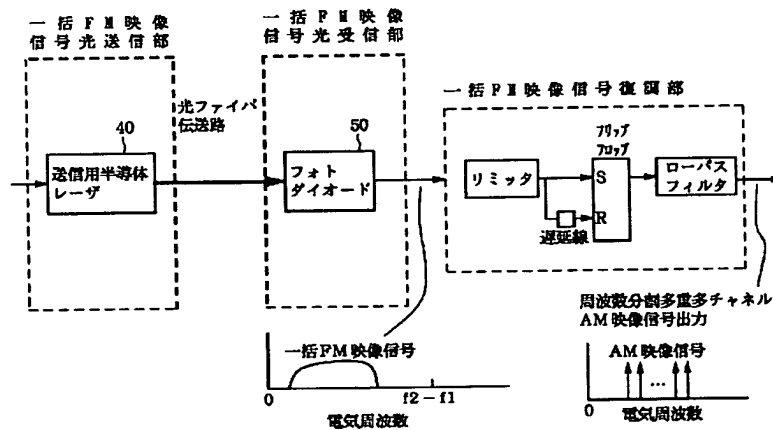
【図6】



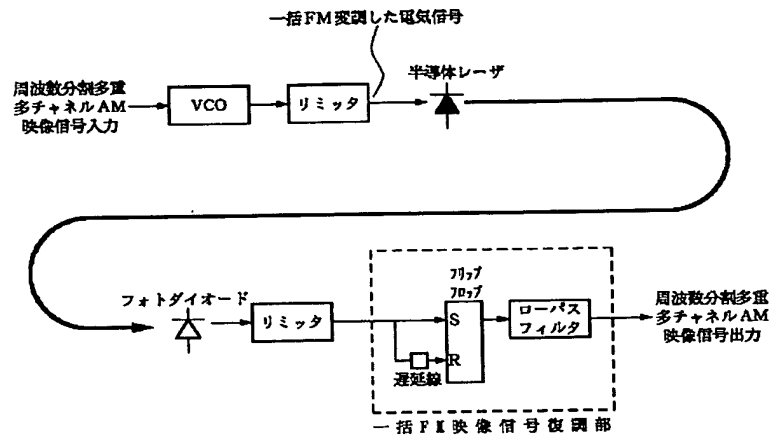
【図7】



【図8】



【図9】



フロントページの続き

(51)Int.Cl.<sup>8</sup>

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